

X. MISCELLANEOUS PROBLEMS

A. ELECTRONIC DIFFERENTIAL ANALYZER

Prof. Henry Wallman

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Three new multiplier-function generators have been built and mounted on the analyzer rack and are undergoing tests.

A new simple time-base generator has also been built and added to the rack. This unit eliminates the use of an integrator each time a function of time is to be generated by the function generators.

The time calibrator and calibrating pulse generator, slightly expanded, has been rebuilt and incorporated in the rack to facilitate the operation of the machine.

Robert H. Cannon, Jr. of the Mechanical Engineering department has been using the analyzer for some time in connection with a speed-boat problem. This work is still in progress.

The Fourier transformer is discussed in forthcoming R.L.E. Technical Report No. 136 by A. B. Macnee.

Dr. Macnee has left this Laboratory to carry out a similar project in Sweden.

R. Maartmann-Moe

B. MATHEMATICAL ANALYSIS OF A SERIES-SHUNT PEAKING CIRCUIT

The series-shunt peaking circuit, shown in Figure X-1 is normally employed as a compensating network in a wide-band amplifier. The shunting resistance across L is used to adjust the circuit for the flat-flat gain characteristic for any value of P. It was desired to determine the relationships between the various circuit parameters as well as the maximum bandwidth available for different values of P for the flat-flat case.

The following represents the solution of work which was begun by A. B. Macnee in February after completing similar work on a series-peaking circuit.

The transfer function for this circuit was expressed as an admittance and results in an expression of the form:

$$Y_{TR} = \frac{1 + a_1\lambda + a_2\lambda^2 + a_3\lambda^3 + a_4\lambda^4}{1 + b_1\lambda + b_2\lambda^2}$$

Setting $\lambda = j\omega$ and squaring gives the squared magnitude of the transfer impedance.

In order to obtain the flat-flat case it is necessary to equate the

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first $n - 1$ derivatives to zero so:

$$|Y_{TR}|^2 = 1 + \frac{a_4^2 \omega^8}{1 + (b_1^2 - 2b_2)\omega^2 + b_2^2 \omega^4} \quad .$$

This results in three equations which must be solved simultaneously for various values of b_1 , b_2 , and a_4 corresponding to assumed values of P . By substituting these values of b_1 , b_2 , and a_4 into the above equation and setting it equal to the admittance at the half-power point, it is possible to solve for the bandwidth, ω . The results are seen in the curves of

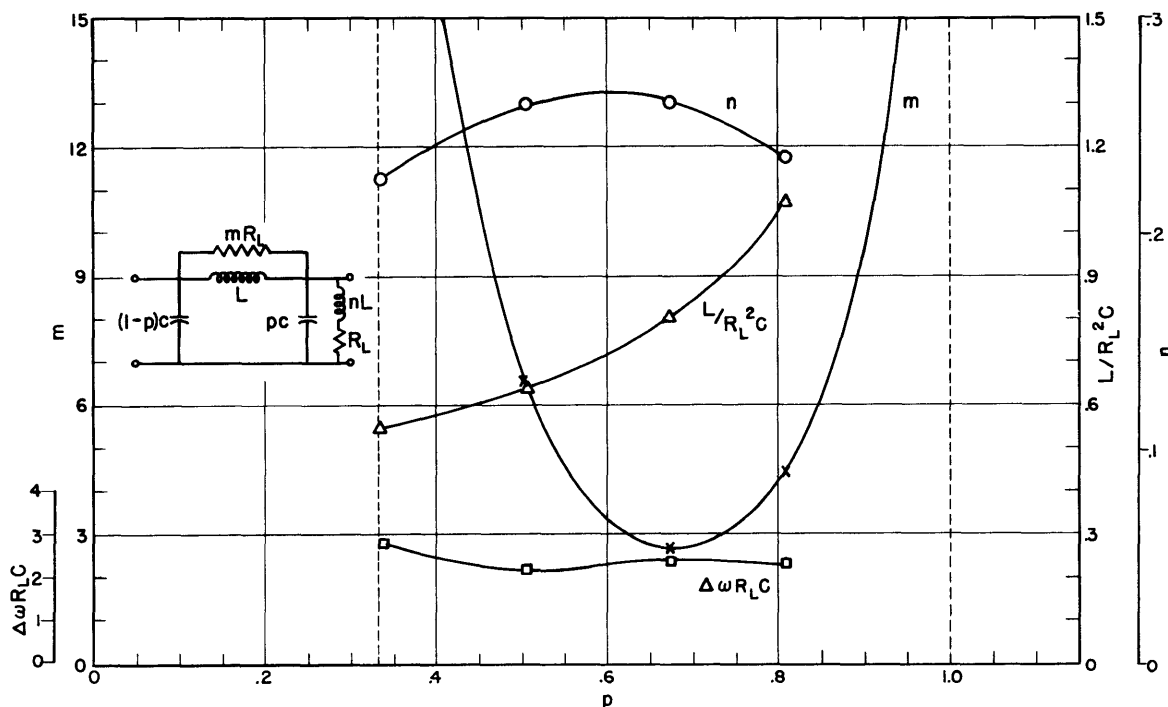


Fig. X-1 Curves of bandwidth factor and other parameters vs. the parameter p in the series-shunt-peaking circuit shown in insert.

Figure X-1. The maximum bandwidth was

$$\Delta\omega = \frac{2.89}{RC} \quad \text{for} \quad P = \frac{1}{3} \quad ,$$

and for this P the shunt resistor is not needed. This corresponds to a gain-bandwidth product of $2.89 g_m / 2\pi C$ and it is equal to 58 percent of the theoretical limit.

E. H. Gibbons

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C. AN AUTOMATIC IMPEDANCE-FUNCTION ANALYZER

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During the last quarter some new components have been added to the automatic impedance function analyzer, and some operating tests have been made. A photograph of the completed machine is shown in Figure X-2. The

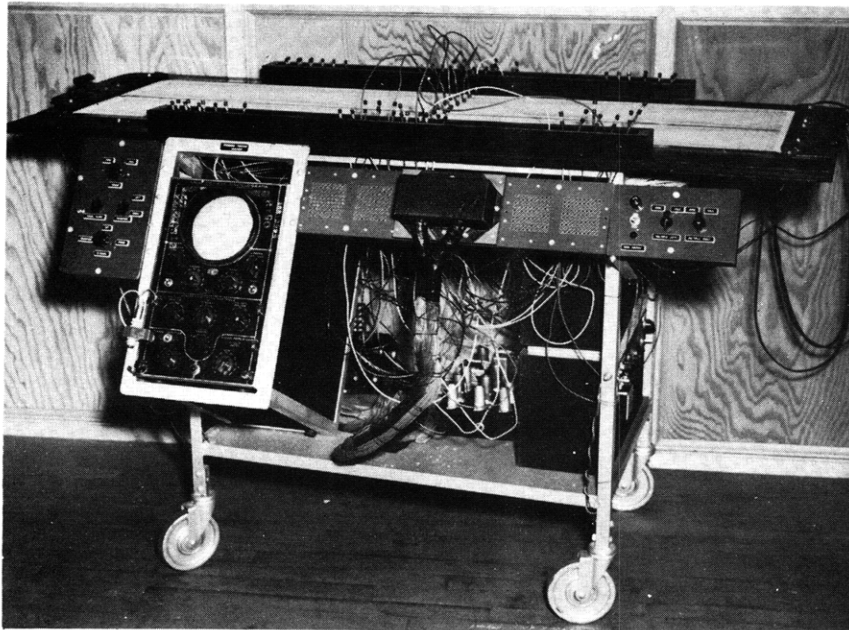


Fig. X-2 Automatic impedance function analyzer showing probe distribution of a Butterworth filter.

probe distribution in the photograph is that of a Butterworth filter whose transfer characteristic is given below.

The poles and zeros are introduced into the complex frequency plane by means of the current carrying probes. The plane itself consists of conducting Teledeltos paper. The magnitude of the impedance function is obtained by measuring the voltage along the imaginary axis in the plane. The phase derivative is obtained by taking the voltage gradient in a direction at right angles to the imaginary axis. The phase is obtained by integrating this function. At the present time the amplitude response is satisfactory but hum and commutator hash interfere with the phase response. It is expected that a great deal of this trouble can be eliminated with a suitable filter.

The machine is calibrated by means of 6-db and 12-db slopes such as

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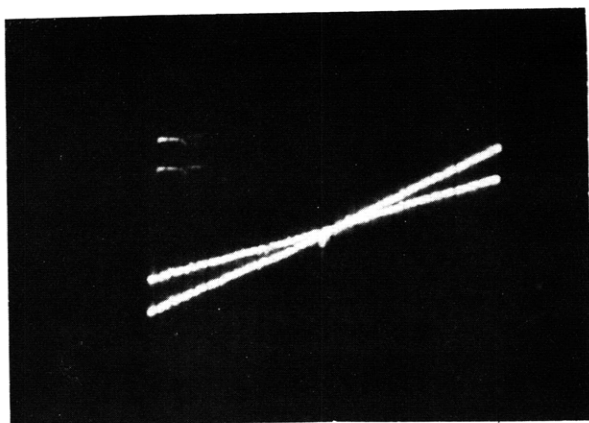


Fig. X-3 Six- and twelve-decibel slopes used for calibration.

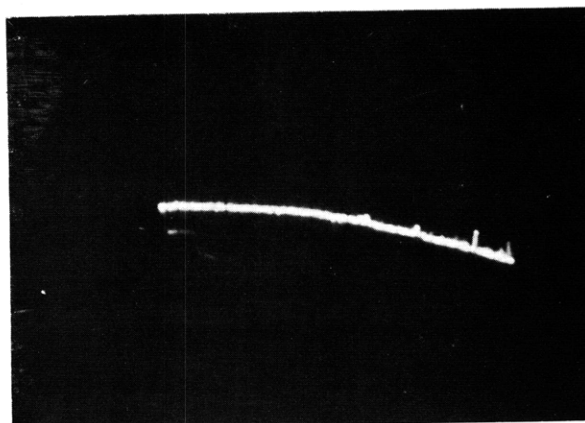


Fig. X-4 Experimental curves of $\frac{1}{1 + Ts}$.

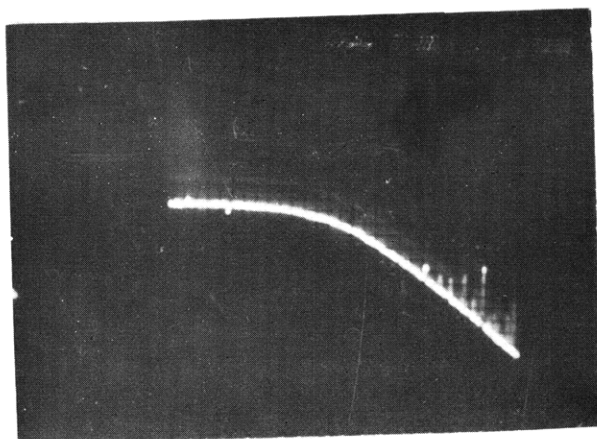


Fig. X-5 Experimental curves of $\frac{1}{T^2s^2 + 2\zeta Ts + 1}$.

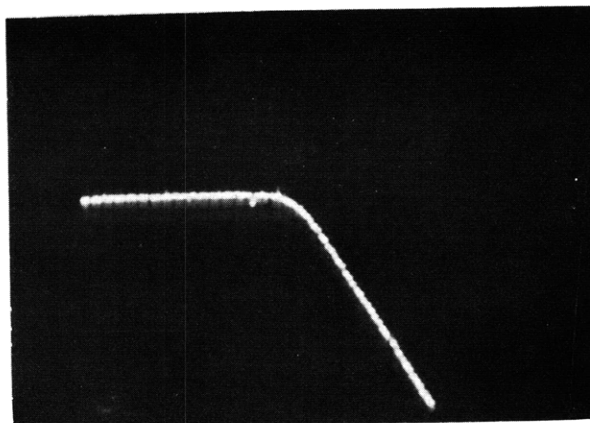


Fig. X-6 The Butterworth filter, $|Z_{12}|^2 = \frac{1}{1 + \omega^{10}}$.

those in Figure X-3. They are obtained by means of a calibrating switch which introduces currents at the origin in the complex plane. The same switch is used, of course, to introduce poles and zeros of the impedance function which occur at the origin.

Figure X-4 and Figure X-5 show the experimentally obtained curves for the basic factors

$$\frac{1}{1 + Ts}, \quad \text{and} \quad \frac{1}{T^2s^2 + 2\zeta Ts + 1}.$$

The middle range of the machine was used and T was set at 1/3 for both factors. The value of ζ in the second was 0.7.

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As an actual example of a filter, a Butterworth low-pass type is shown in Figure X-6. This filter is represented by the transfer function

$$\left| Z_{12} \right|^2 = \frac{1}{1 + \omega^{10}} \quad .$$

The poles lie on the unit circle in the s plane and are equally spaced. In the logarithmic plane they lie on a line at right angles to the imaginary axis, but the spacing remains uniform. It is this configuration which is set up on the machine for the picture shown in Figure X-2.

A more complete description of the machine and of its operation will be given in the forthcoming R.L.E. Technical Report No. 137, "An Analog Device for Solving Problems in Network Synthesis", by R. E. Scott.

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